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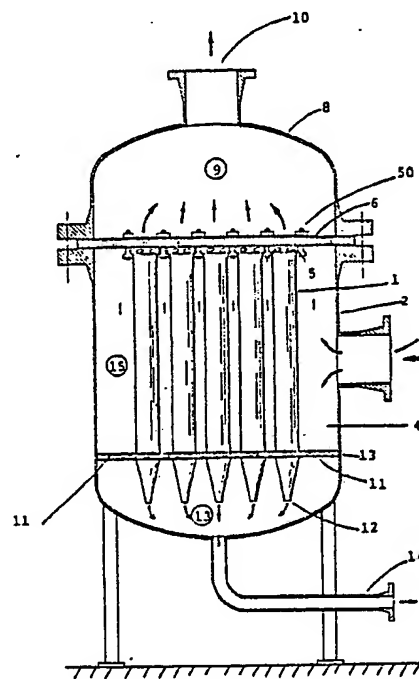
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: CYCLON PURIFICATION PLANT

(57) Abstract

Hydrocyclon plant for separating solid particles from liquid in which a number of hydrocyclons operates in parallel, comprises an outer chamber (2) divided in three compartments (9, 15, 13) and in which the accept openings (120) of the cyclons lead into a chamber (9) being provided with an outlet (10) for the accept, the inlet openings (5) for the cyclons (1) are arranged in the chamber (15) to which the liquid (4) to be treated is injected via an inlet opening (3) and in which the reject openings (12) of the cyclons opens to the chamber (13) which is connected with an outlet (14) through which the reject is exhausted.



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## Cyclon Purification Plant.

The present invention relates to a hydrocyclon plant for separation of suspended solid from a liquid. The plant is particularly adapted to separate suspended particles from water, for instance filler particles in effluence from paper mills or to remove a part of the filler being present in the white water system in a paper machine. As the plant exhibits large capacity, is compact and easily maintained it is well suited in all cases in which particles in a liquid can be removed by means of a hydrocyclon. The plant is well suited when it is desirable to remove fine particles from a liquid. This is particularly so when in the plant is utilized a cyclon of the type being disclosed in Norwegian Application No. 83.0058.

Hydrocyclons being used in the present device are well known and a short account can be found inter alia in Encyclopedia of Chemical Technology, 2nd edition volume 4 pp. 747-748.

Hydrocyclons are well adapted for removing of fine particles being present in low or medium solid concentrations. Due to share forces being present in the vortex in the hydrocyclons, separation is not effected by the centrifugal force alone but the form of the particles exerts a certain effect. Hydrocyclons have thus been used in the pulp and paper industry in order to separate fibers of different length.

Normally a hydrocyclon consists of a rotation symmetrical, elongated hollow body which under working condition is arranged in a vertical position and the upper end of which is provided with at least one tangential directed inlet through which the liquid to be treated is injected with high velocity in such manner that a vortex stream is created in the hydrocyclon.

In the upper part of known cyclons is a centrally arranged outlet opening, the cross sectional area of which is larger than the combined cross sectional area for the inlet openings. Through the upper outlet opening is exhausted the injected liquid now fully or partly derived of solid particles.



In the lower part of the hydrocyclon is arranged a central outlet opening, the cross sectional area of which is less than the cross sectional area for the inlet openings and serves as an outlet for a minor part of the injected liquid which at the lower part of the hydrocyclon is enriched with respect to solid matter.

The rotation symmetrical hollow body which in the length direction can be designed conically such as shown in US patent 2.920.761, or can be cylindrical in the upper part with a conical lower part such as shown in Norwegian Patent No. 144.128. In order to adapt the hydrocyclons for different purposes and in order to improve the efficiency, different modifications of such hydrocyclons have been suggested, for instance with respect to the inlet for the liquid to be treated, as shown in the above mentioned Norwegian Patent or with modification of the outlet for the part of the liquid enriched with solid matter, such as shown in US patent No. 4.309.238.

Particular outlets for the purified liquid is shown in US patent No. 4.259.180 and French patent No. 1.518.253.

Different types of hydrocyclons are inter alia disclosed in the US patent No. 4.265.470, 4.280.902, 4.305.825, 4.267.048 as well as in US patent No. 4.272.260 which discloses a cyclon for separation of solid particles from gasses.

It is commonly known to couple a number of cyclons in parallel, that is the inlets of the hydrocyclons are connected to a common pipe and the outlets from the cyclons from the purified liquid is connected to a common pipe whereas the respective outlet for the liquid phase being enriched with respect to the particles is exhausted via a common pipe connected to the lower part of the hydrocyclons. Such a plant comprising a number of hydrocyclons is spacious and it is difficult to obtain equal conditions for all cyclons with the result that not all cyclons in such a battery of cyclons will work under optimal conditions.



By means of the present invention is provided a compact plant by means of which it is possible to have a number of cyclons working under essential equal conditions in that all cyclons are enclosed in a chamber in such manner that all the cyclons are provided with the liquid to be treated under the same pressure.

The invention shall be elucidated with reference to the enclosed drawings, in which:

10

Fig.1 shows a section through a plant according to the invention.

Fig. 2 discloses one of two essentially identical partitions which partly are used to divide the chamber, in which the hydrocyclons are arranged, to compartments and partly to secure the cyclons within the chamber.

Fig. 3 shows a horizontal projection of the upper part of a cyclon with a particularly designed inlet as well as a detail of the fastening device for the cyclon to the partition.

In fig. 5 is shown how the lower part of the cyclon extends through the lower partition, which is designed in the same manner as the upper partition.

In fig. 1 is shown how a number of hydrocyclons 1 are arranged within a common chamber 2. Water 4 or the liquid to be treated is injected from a not shown feed pump to the compartment 15 via the inlet 3, whereby the cyclons 1 are surrounded by water 4 under the preferred pressure, hence the water is injected to the inlet dyse 5 of each hydrocyclon. All the hydrocyclons will thus be provided with water or the liquid at essentially the same pressure. In the upper part of the compartment 15 is arranged a close fitting partition 6 provided with holes 7 for each cyclon 1. The partition 6 is removable connected to the chamber such that all cyclons, if necessary simultaneously can be lifted out of the chamber.

A tight fitting lid 8 comprises the upper part of the chamber 2 such that under the lid is formed a compartment 9 being separated from the water underneath the partition 6. The outlets for purified water from all cyclons opens up in the compartment 9 being formed between the lid 8 and the partition 6. The purified water or the accept is exhausted via the outlet tube 10.

In the lower part of the chamber 2 is arranged a further partition 11. The lower partition 11 is preferably arranged tight fitting to the wall of the chamber 2 and is provided with corresponding holes 7 as in the plate 6 and through which the lower outlets 12 of the hydrocyclons extends in a tight fitting manner such that the water 4 in the compartment 15 being defined between the two partitions 6 and 11 respectively cannot penetrate to the void 13 underneath the partition 11.

From the reject outlet 12 of the cyclons is exhausted a minor part of the injected liquid. As usual for hydrocyclons said part being enriched with respect to the solid phase of particles being separated from the feed water injected to the inlet tube 3. The enriched phase or reject is removed from the void 13 via the outlet tube 14.

The cyclons 1 being arranged in the chamber 2 can be of a type known per se being secured to the partition 6 and the inlet 5 which is arranged underneath the partition such that water 4 being introduced via the inlet 3 can be forced into the inlet 5 of each cyclon. The cyclons 1 are preferably of the type described in Norwegian Patent Application No. 83.0085. Said cyclon is characterized by a large capacity and ability to separate very small particles. The liquid being introduced to the cyclon 1 through the inlet 5 is lead into a rotation forming chamber 40 being defined between the inner wall of the cyclon 1 and a guiding tube 20 having a conical form and with a conicity in the range  $4-10^{\circ}$ . The rotating liquid stream is forced down through the cyclon and returns as usual in its lower part and the ascending,



purified liquid or accept is lead out through an annular outlet 120 being defined between the guide tube 20 and especially designed body 110 to the chamber 9 and out of the plant via the outlet 10.

5

In the preferred used cyclon the liquid is not exhausted through a central outlet, such as usual for common cyclons, but through the annular outlet 120 being formed between the conical tube 20 and the centrally arranged body 110. The body 110 is secured to a director plate 90 which directs the stream into the compartment 9 above the partition 6 and out through the outlet 10.

In order to aid replacement of the cyclons 1 the same are fastened by means of a fastening device 50, which in fig. 1 is shown to comprise a through bolt 51, a collar 52 engaging the flange 53 on the cyclon 1. The collar 52 being secured by means of the bolt 51 thus support the cyclon 1 which firmly is held engaged against the collar 52 by means of a collar 54 being secured by means of the nut 55.

In the lower part the cyclon 1 is passed through corresponding holes 7 in the partition 11, as indicated in fig. 5. In order to prevent leakage of the injected liquid 4 to the compartment under the partition 11 a ceiling ring is provided in a groove in the partition, for instance an O-ring as indicated in fig. 5. Other ceiling and fastening devices is of course possible.

In a hydrocyclon plant according to the present invention containing 85 hydrocyclons of the preferred type the height of the chamber was 3,3 m and the diameter 1,37 m. The diameter of the individual cyclons was approx. 7,6 cm.

The device was used to separate solid particles from sea water and the number of particles of the sea water introduced as well as the accept water was determined by means of a "COULTER COUNTER TAIL". The sea water was introduced at a pressure of 2,1 bar at which pressure each cyclon had a capacity of 150 l/min., that is the total capacity of the plant was approx.

12 750 l/min. The separation efficiency of the plant is apparent from the following table:

COULTER COUNTER TAIL

5

Liquid: Sea water

Place: NUTEC, Bergen

	Particle diametre um	Number of particles per ml of feed water	Number of particles per ml in accept water	<u>Efficiency</u>	
				Percentage of particles removed	Accumulated percentage, particles larger than
10					
15	1.0-1.25	22436	17072	23.9	75.4
	1.25-1.6	10578	8095	23.5	76.7
	1.6-2.0	6268	4357	30.5	78.1
	2.0-2.5	4651	2971	36.1	79.5
	2.5-3.2	2765	1529	44.7	81.6
20	3.2-4.0	1727	759	56.1	83.8
	4.0-5.1	1084	299	72.4	86.0
	5.1-6.4	707	107	84.9	87.6
	6.4-8.0	423	58	86.3	88.1
	8.0-10.1	233	26	88.8	88.6
25	10.1-12.7	100	9	91.0	88.5
	12.7-16.0	39	6	84.6	87.1
	16.0-20.2	19	3	84.2	88.8
	20.2-25.2	2	0	100.0	100.0
	25.2-32	1	0	100.0	100.0

As apparent an excellent separation and high capacity is  
35 obtained by means of the new cyclon plant.



## C l a i m s

- 5 1. Cyclon plant to separate solid particles from a liquid  
comprising a number of hydrocyclons coupled in parallell,  
c h a r a c t e r i z e d i n an outer chamber (2)  
divided in three compartments (9,12,13) in that the accept  
outlets (120) of the cyclons lead into the chamber (9)  
being provided with an outlet (10) for the accept, that the  
10 inlet openings (5) of the cyclons (1) is arranged within  
the compartment (15) to which the liquid (4) to be purified  
is introduced via the inlet opening (3) and that the reject  
outlet openings (12) opens into the chamber (13) being  
connected to an outlet (14) for removal of the reject liquid.  
15
2. Device according to claim 1, c h a r a c t e r i z e d  
i n that the chamber (2) by means of partitions (6,11),  
provided with holes (7) is divided in compartments (9,15,13),  
and that the upper part of the cyclons by means of a fixing  
20 device (50) is secured to the partition (6) with the accept  
openings (120) of the cyclons (1) leading to the chamber  
(9) and that the inlet openings (5) of the cyclons are  
arranged underneath the partition (6) and that the cyclons  
(1) extend through the partition (11) with the reject open-  
25 ings (12) of the cyclons opening into the chamber (13) under  
the partition (11).
3. Cyclon device according to the claims 1 and 2,  
c h a r a c t e r i z e d i n that the cyclon (1) is  
30 provided with a centrally arranged body (110) which together  
with an annular tube (20) forms an annular outlet (120) to  
the chamber (9) for the accept liquid.
4. Device according to the claims 1-3, c h a r a c t e -  
35 r i z e d i n that the inlet openings (5) for the  
cyclons (1) lead into a vortex forming chamber (40) defined  
between the inner wall of the cyclon and the guiding tube  
(20).

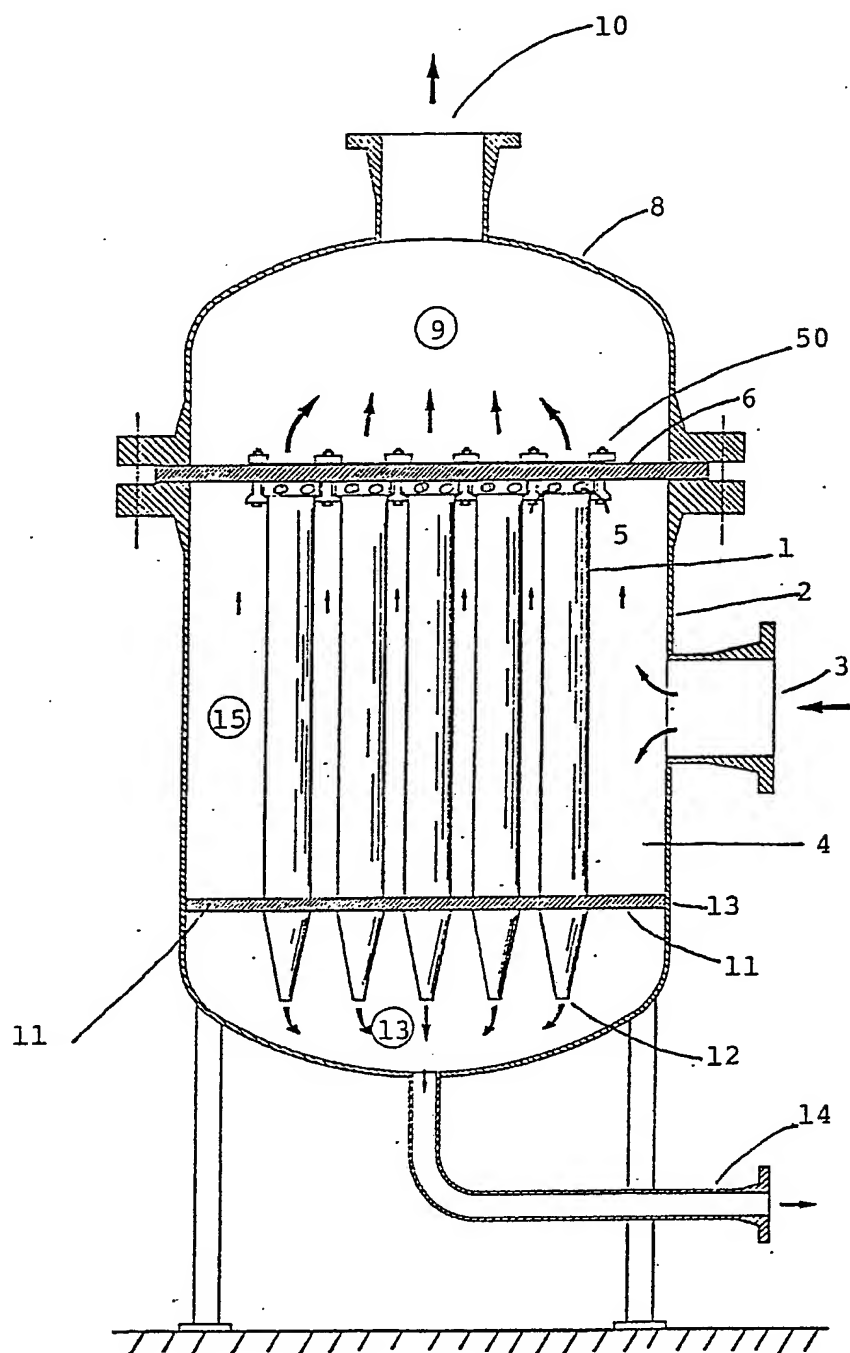


Fig. 1

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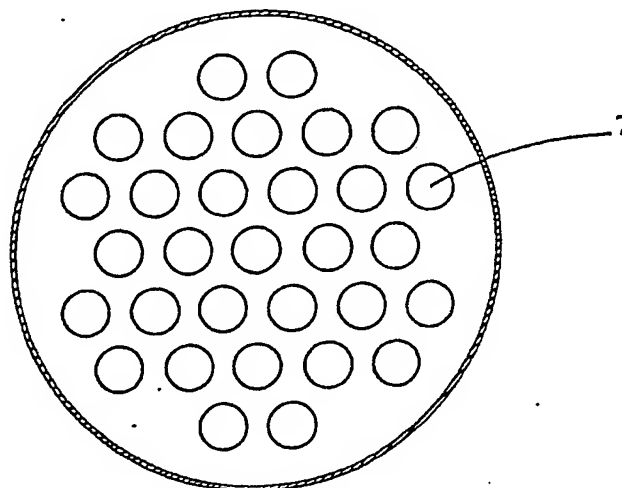


Fig. 2

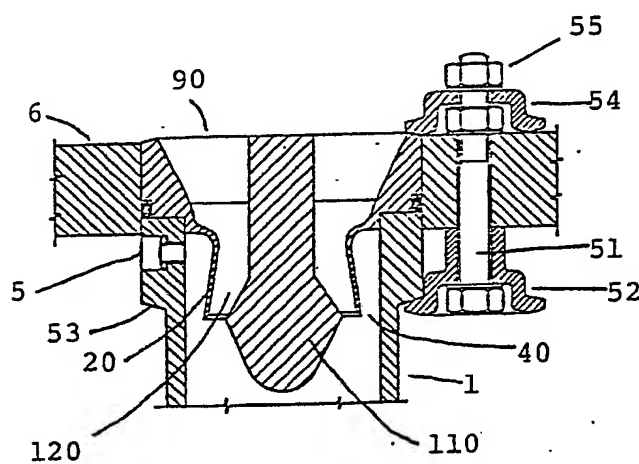


Fig. 3

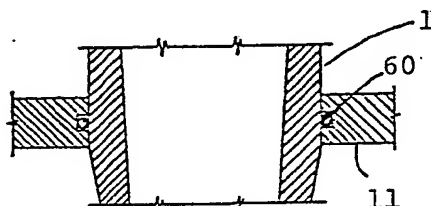


Fig. 4

# INTERNATIONAL SEARCH REPORT

International Application No **PCT/N083/00008**

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC <b>3</b> <div style="text-align: center; margin-top: 10px;"><b>B 04 C 5/28</b></div>																	
<b>II. FIELDS SEARCHED</b> <div style="text-align: right; margin-right: 100px;">Minimum Documentation Searched *</div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%; padding: 5px;">Classification System</td> <td style="padding: 5px;">Classification Symbols</td> </tr> <tr> <td style="padding: 5px;">IPC 3 US C1</td> <td style="padding: 5px;">B 04 C 5/04, 107, 13, 28 <u>209:211</u></td> </tr> </table> <div style="text-align: center; margin-top: 10px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *</div> <div style="text-align: center; margin-top: 20px;">SE, NO, DK, FI classes as above</div>			Classification System	Classification Symbols	IPC 3 US C1	B 04 C 5/04, 107, 13, 28 <u>209:211</u>											
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<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> 14 <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; padding: 5px;">Category *</th> <th style="width: 60%; padding: 5px;">Citation of Document, 14 with indication, where appropriate, of the relevant passages 17</th> <th style="width: 30%; padding: 5px;">Relevant to Claim No. 18</th> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">SE, B , 373 760 (WIKDAHL) 17 February 1975 Fig 1 with appr. text</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1, 2</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">SE, B, 419 042 (ENSO GUTZEIT OY) 13 July 1981</td> <td style="text-align: center; vertical-align: top; padding: 5px;">4</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">US, A, 2 765 918 (FONTEIN ET AL) 9 October 1956</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1, 2, 4</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">US, A , 4 148 723 (NATIONAL RESEARCH DEVELOPMENT CORPORATION) 10 April 1979</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1, 2, 4</td> </tr> </table>			Category *	Citation of Document, 14 with indication, where appropriate, of the relevant passages 17	Relevant to Claim No. 18	X	SE, B , 373 760 (WIKDAHL) 17 February 1975 Fig 1 with appr. text	1, 2	A	SE, B, 419 042 (ENSO GUTZEIT OY) 13 July 1981	4	X	US, A, 2 765 918 (FONTEIN ET AL) 9 October 1956	1, 2, 4	X	US, A , 4 148 723 (NATIONAL RESEARCH DEVELOPMENT CORPORATION) 10 April 1979	1, 2, 4
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: 15</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"Δ" document member of the same patent family</p> </div> </div>																	
<b>IV. CERTIFICATION</b> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">Date of the Actual Completion of the International Search *</td> <td style="width: 50%; padding: 5px;">Date of Mailing of this International Search Report *</td> </tr> <tr> <td style="text-align: center; padding: 5px;">1983-06-21</td> <td style="text-align: center; padding: 5px;">1983-07-06</td> </tr> <tr> <td style="padding: 5px;">International Searching Authority *</td> <td style="padding: 5px;">Signature of Authorized Officer 20</td> </tr> <tr> <td style="text-align: center; padding: 5px;">Swedish Patent Office</td> <td style="text-align: center; padding: 5px;">            C. Westberg         </td> </tr> </table>			Date of the Actual Completion of the International Search *	Date of Mailing of this International Search Report *	1983-06-21	1983-07-06	International Searching Authority *	Signature of Authorized Officer 20	Swedish Patent Office	C. Westberg							
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**FURTHER INFORMATION CONTINUED FROM THE FIRST SHEET**  
(Not for publication)

Numeral 120 (line 10) in the abstract should read 12.